PROBLEMS OF URBANIZATION IN THE HIGH ARCTIC

- H.P. Wilson -

Arctic Weather Central
Atmospheric Environment Service
Edmonton, Alberta

For Presentation at the 1971 Annual Meeting
of the Air Pollution Control Association
Calgary, Alberta November 21-23, 1971

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ABSTRACT

Assuming that a town will be built somewhere in the High Arctic within a few years, it seems probable, from consideration of economic and physical factors, that it will be located on a south coast, where there is a bay to serve as a harbor, and where there is a lake for a water supply. With modern sanitary engineering, the town itself will not cause significant pollution, but processing plants or smelters may present serious problems in this respect.

INTRODUCTION

Because of the great potential for oil and mining development in our Arctic, and the current high level of exploration activity, it seems almost certain that at least one urban community will be established within the next five years or so to exploit a very large resource. If so, there will be a great deal of interest in, and concern with, possible air and water pollution, ecological damage, and social problems which may result from the building of such a town. As many of the people here are likely to be involved in some way, this would appear to be a good place and time to consider what such a town would be like in order to get a better idea of what the real problems will be.

Obviously and admittedly, an Arctic Meteorologist is not qualified as an expert on town planning. However if one considers the major economic and environmental factors which must be taken into account, it soon becomes apparent that there will not be very much leeway for those who will build the town. For this reason, we non-experts can make tentative but realistic estimates of where and how the town will be constructed, and these ought to enable us in a crude way to forecast how the town will affect the environment.

SITE SELECTION FACTORS

1. Oil towns in Alberta, such as Devon and Drayton Valley have populations around 1,500. Mining towns vary more widely. Pine Point has about 800 and Thompson about 15,000. From these figures, our Arctic town could range in size from 1,000 to 20,000 people. However, we must bear in mind that only very large finds will be exploited in the far north because of relatively high tranportation costs. Also, the town will need to have more complete facilities and services than are necessary at Devon or Thompson because of the great distances from major centers. For these reasons, our Arctic town is likely to have more than 1,000 people, but for convenience that figure will be adopted to simplify the arithmetic.

Also, for convenience let us call our town Bernier, in honour of the very fine man who was the first Canadian to lead expeditions to our high Arctic and who formally established our claim to the Arctic islands.

WATER TRANSPORT

2. Simply because water transport is by far the cheapest for moving bulk supplies, Bernier will be located as close as possible to a harbour for shipping. Because of the ice hazard, the harbour will be located on a protected channel or on a south or southeast coast, if possible.

AIR TRANSPORT

3. An airport is of course a vital necessity for the transportation of people and many items of supply. A runway 5,000 feet in length is a minimum, and at many possible sites, a second runway could increase the useability of the airport significantly.

Raised beaches or eskers are best because little work is required to convert them into runways. A low ridge with good natural drainage can also be used. Otherwise it is necessary to find an ample source of gravel to build up the runway, taxi way, parking area and access roads on flat terrain.

With regard to weather, a site south or southeast of higher terrain is preferable generally.

Also, the airport ought to be within a mile or so of Bernier for convenience and lower costs.

WATER SUPPLY

4. Obviously, an adequate water supply is of major importance. Unfortunately, there are very few rivers in the Arctic that could be used for this purpose, mainly because most of the annual volume of flow is discharged within two weeks when the snow is melting in June. The construction of a dam to impound the runoff could be rather expensive because of a lack of suitable fill material, and the necessity for thawing the soil by the use of steam before it can be excavated.

A lake within a mile or two appears to be the best solution. Allowing 30 gallons per person per day, and assuming a net gain of two inches per year from precipitation, about one third of an acre of lake area would be required for each member of the population.

To preclude freezing of the supply line, it would be necessary to heat the water, and possibly also to use a circulating system such as has been used at Churchill.

GRAVEL AND SAND

5. As indicated earlier, an adequate supply of gravel and sand could be of critical importance during construction, and therefore a significant factor in site selection.

Again because of permafrost, it will be necessary to use steam to make removal possible.

SEWAGE

6. According to Mr. Jack Grange, our authority on sanitary engineering for the Arctic, sewage lagoons, properly located and constructed can be used in the Arctic as effectively as in southern Canada

Although the decomposition processes are inactive most of the year, the 24-hour sunlight of the short summer is sufficient for an annual cycling.

As the costs of construction of a utilidor system, like the one in Inuvik, are very high, it is necessary to avoid any unnecessary length. For this reason, Bernier is likely to be a complex of large buildings and apartment blocks, with a utilidor located along a central connecting passageway, rather than a collection of individual buildings and houses.

To avoid the cost of pumping, the sewage line will probably be built with the required slope through the town and the town located at a higher elevation than the lagoon.

GARBAGE

7. Again, according to Mr. Grange, burial in a pit or trench is the best method available for the disposal of garbage. Because of permafrost, the garbage will remain fresh and in place for a very long time.

CONSTRUCTION

Because wood is relatively easy to manipulate and shape, lasts almost indefinitely in the Arctic, and is a good insulator after it dries out in the dry Arctic atmosphere, it seems probable that lumber will be used extensively in the construction of Bernier.

As dry wood burns readily, great care will be taken to include many firewalls and firedoors in the buildings.

To keep noise levels down, sound insulation will be used to a greater degree than usual.

External doors and windows will be fewer in number because of the

problem of blowing snow, but also because of the fact that there are nearly 4 months each of continuous darkness and continuous daylight. In other words, the lighting will be largely artificial.

Very few of the population will be required to be out-of-doors during the winter dark. For this reason, it will be necessary from the morale point of view to provide generous living and working space, and better facilities, such as a library, a gymnasium, and a hobby shop, than are ordinarily available in a town the size of Bernier.

Costs of construction will probably be 3 times our national average. Allowing $50 per square foot, 300 sq. feet per person for living space and 400 for work, recreation, and facilities, the cost would be $35,000,000. Equipment of various kinds, the airport, and water and sewer systems could easily cost another $15,000,000, so that Bernier could have a price tag of the order of $50,000,000. Obviously, the oil or mineral deposit will have to be very large to justify such an expenditure.

THE ENVIRONMENT

Before discussing the various aspects of the pollution problem it is necessary to review the main physical factors that will be involved. First of all, the mean annual temperature will be near 10°F, and temperatures above freezing will prevail from mid-June to early September. The winters are little more severe than say at Saskatoon, but they are much longer. Actually, most people find the darkness of winter more trying than the usual temperature of 0 below.

Throughout the year, but particularly in winter, there is usually an inversion of temperature some distance above the surface. The height of the base tends to increase with wind speed. With light winds the base may be within 100 feet of the surface, and with strong winds, well above 500 feet. The maximum possible upward increase of temperature is about 40°F, under steady conditions. The thickness of the inversion layer can vary widely.

With maximum intensity it may be as shallow as 1,000 feet or as thick as 7,000 feet.

In summer, strong inversions are less frequent and often there is no inversion, particularly over the interior of large land masses.

With regard to marine areas, there is an annual variation of water motion. In winter, the water below the ice is nearly stagnant because of the lack of motion of the ice. The water can move only in response to hemispheric influences, and the net result is a slow flux of water from northwest to southeast through the deeper channels.

In summer, when the ice is broken, surface stresses from the wind tend on the average to move ice and water southeastward.

In addition, of course, we have tidal motions, but they are not very effective in transporting water.

Northern lake water remains stagnant under the ice in winter except where there is a flow of water because of rivers. In summer, the water is moved about by the winds, and it tends to overturn when the surface water rises or declines through the temperature of 39°F. The deep water in northern lakes normally has a temperature of 39°F, the temperature of maximum density.

POLLUTION REMOVAL

Because of the intensity and general lack of turbulence within Arctic inversions, pollutants tend to be trapped at the bases of inversions at relatively low levels, particularly in winter. The dispersal is much more rapid in summer.

Actually, ventilation, can be much more effective than turbulence in the removal of atmospheric debris. For this reason, there is some advantage in selecting a windy site, such as on a ridge on a cape, or along a coast with high terrain inland.

In general, the dumping of wastes of any kind into water ought to
: avoided. except possibly at the mouth of a river in winter, or into sea
ıter in summer, assuming that ecological damage does not result.

)LLUTION SOURCES

As Bernier will almost certainly be centrally heated except for
ıe building or buildings at the airport and the pumphouse at the water
ıtake, and we can assume that the heating and power plants will be modern
ıd efficient, there ought to be very little air pollution from the town
.self. Similarly, the garbage and sewage disposal systems may be expected
) be clean in this respect.

Although gas and oil gathering systems sometimes leak, routine
ıintenance ought to prevent any serious troubles. There seems to be a
'eater risk of accidents when wells are being drilled than after they have
:en put on production.

Field treatment plants appear to be the worst offenders, at least
.th regard to disagreeable odors. However, they do not otherwise cause
:rious pollution, apparently.

In general then, an oil town and field with proper engineering
ıd construction are likely to be relatively free from obnoxious air pollution.

Although ice fog is not really pollution in the ordinary sense of
ıe word, the heating and power plants will certainly produce considerable
ıantities, which could limit visibility and affect operations at the airport.
)r this reason the airport ought to be located upwind from the town with
:spect to local drainage winds.

For a mining town, if there is a pollution problem, it will probably
: the result of the operation of a smelter, which may be needed to reduce
'ansportation costs.

There is also possibilities at Bernier for what might be called thermal pollution. If there is a discharge of hot water from the heating and power plants, harm could be done to the local fish population. This could be avoided by recirculating the water rather than discharging it.

If the oil comes from great depth and is hot, there would b heating of the soil around the gathering lines. Gas lines do not heat the soil because pressure reduction at the well heads reduces temperatures so that the gas lines are relatively cold. However, oil directly from the well head can be hot enough to raise soil temperatures significantly by heat loss through the insulation. This could cause some melting of the ice content of a soil, but it could also promote vegetative growth. Thus whether or not the heating is harmful depends on your point-of-view.

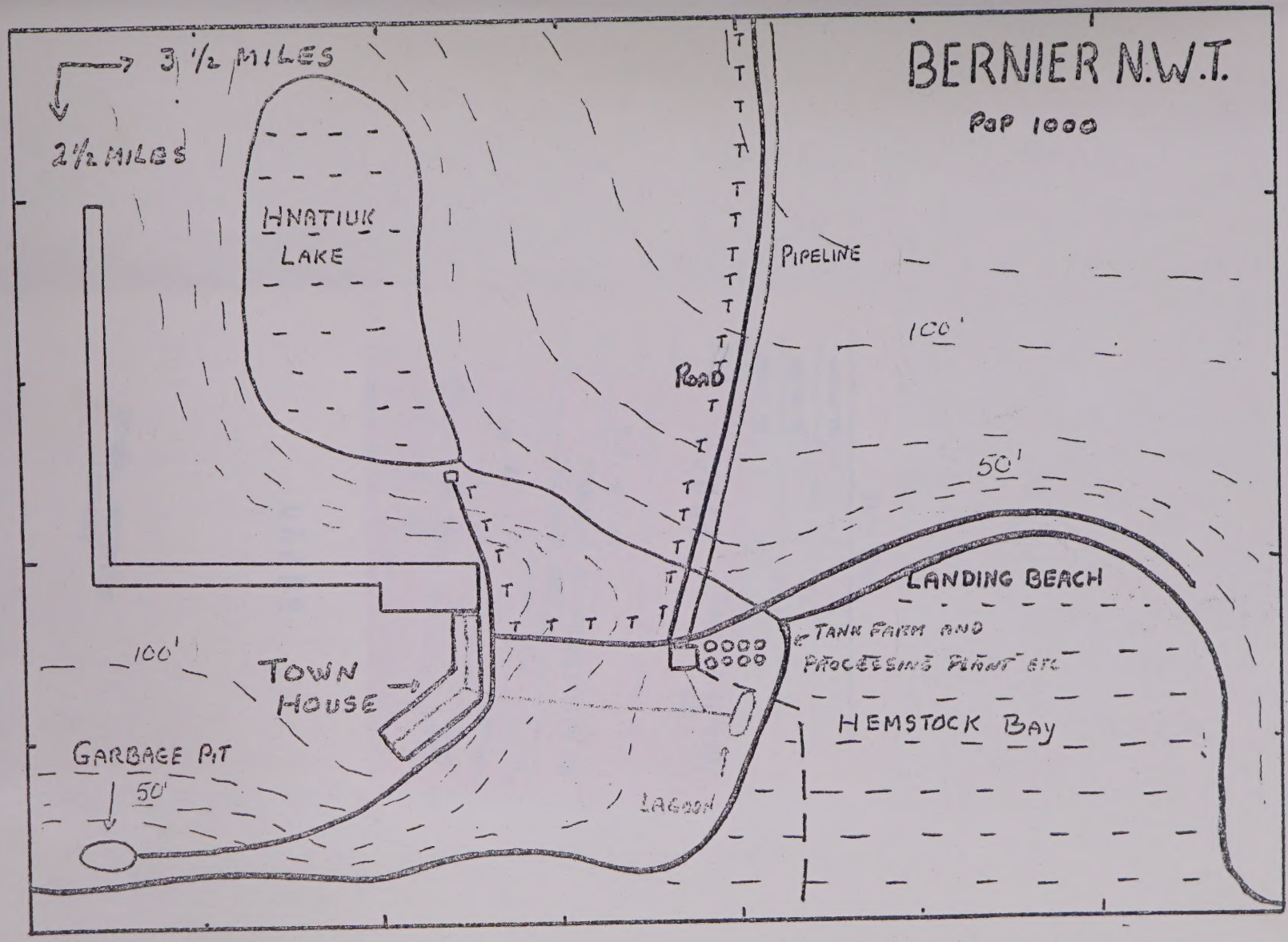
It may be of interest to give a little rule. Ordinarily, the mean annual temperature of the soil near the surface is 9°F higher than that of the air temperature 4 feet above the surface, and temperatures increase with depth at the rate of 1°F per 100 feet, as a rough average. Thus if the mean annual temperature at Bernier is 10°F, that of the soil is 19°F, 13° below freezing, and the depth of permafrost can be estimated to be 1,300 feet. Also an oil well 10,000 feet deep would produce oil at a temperature of 119°F, roughly. This suggests the possibility of utilizing the oil as a direct source of heat for Bernier, if it becomes an oil town.

Last, but possibly not least, there will almost certainly be a problem which might be called people pollution. After being cooped up for 4 months during the winter dark, the residents will take every opportunity to get out of doors during the spring and summer months. No doubt skiing and snowmobiling will be very popular activities from April until early June because of the long sunny days, regardless of the low temperatures. From the end of June until about the end of September. hiking. picnicking and boating will be the main pastimes, and in all of these activities there will be a strong urge toward exploring the country side. If so, the local flora and fauna could take quite a beating, and the landscape will be redecorated with the usual refuse.

In addition, Bernier will attract many visitors, such as tourists, thusiasts for the Arctic, scientists, genuine and otherwise, geologists d mining people, protesters, and scads of company and government officials. will have to make our reservations early.

NCLUSION

On the whole, Bernier may be expected to be a model town which ll not be a detriment to the environment or the ecology. For my part, if rnier provides work and good living for a few hundred of our Eskimos or dians, it would be a very, very welcome addition to our Canadian Arctic.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